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BOTANY.—*The American species of Maximiliana (Cochlospermum).* S. F. BLAKE, Bureau of Plant Industry.[1]

The principal genus of the small family Cochlospermaceae is that which has generally been known under the name *Cochlospermum*, given it by Kunth in 1822. Three years previously Schrank had published for another species of the same genus Martius' manuscript name *Maximiliana*, and it is this name which must be employed for the genus under the American Rules. Martius' single species was named *Maximiliana regia* in honor of King Maximilian of Bavaria. Unfortunately, Martius was not satisfied with this dedication and employed[2] the same name (in the spelling *Maximiliana*) a few years later for a species representing a new genus of palms, for which it has generally been adopted. Simultaneously he proposed the name *Wittelsbachia* for the genus which he had earlier called *Maximiliana*, Kunth's name *Cochlospermum* being rejected because of the prior *Cochliospermum* of Lagasca.

In 1847 Planchon published a revision of the family Cochlospermeae. He[3] divided the genus *Cochlospermum* into two subgenera: *Eucochlospermum*, including as American species *Cochlospermum insigne* and *C. hibiscoides;* and *Diporandra*, containing three species, all American, two of which were described as new. The first subgenus was characterized by its strongly imbricated sepals, free filaments, anthers opening by a single apical pore, reniform seeds, and palmatifid leaves; the second by its slightly imbricated sepals, irregularly subconnate filaments, two-pored anthers, twisted seeds (?), and digitate leaves. This classification was followed in Eichler's treatment in the *Flora Brasiliensis*.

[1] Received January 15, 1921.

[2] Hist. Nat. Palm. 2: 131. 1824.

[3] Lond. Journ. Bot. 6: 306–311. 1847.

In a collection recently made by Mr. Henri Pittier in Venezuela is a new species of this genus, which combines to some extent the characters relied upon by Planchon and Eichler for the separation of their subgenera. The leaves are digitately trifoliolate, but the anthers open by a single terminal pore and two tiny basal pores. Another species, described from Bolivia by H. Hallier, has digitate leaves and anthers opening by two apical pores and two smaller basal pores. Hallier raised the question whether these basal pores may not have been overlooked in other species of the subgenus *Diporandra*, but was prevented by lack of material from determining this point. There are in the National Herbarium no flowers of any of the previously described species of this subgenus, so that the question remains an open one, but it is probable, from the fact that two minute lateral basal pores are found in the anthers of *M. vitifolia*, of the group *Eucochlospermum*, that they occur in all the species.

The species of *Maximilianea* are shrubs or trees, with alternate palmatifid or digitate leaves and short panicles of handsome yellow flowers. The inner bark of two species (*M. regia* and *M. vitifolia*) is used in Brazil and Mexico for making ropes and cord, and the latter species (*M. vitifolia*) is sometimes grown as a hedge plant in the American tropics, but in general the genus is of little economic importance.

Maximilianea Mart.; Schrank, Flora **2**: 451. 1819.

Cochlospermum Kunth, Malv. 6, footnote.[4] 1822; H. B. K. Nov. Gen. & Sp. **5**: 297, footnote. 1822.
Wittelsbachia Mart. & Zucc. Nov. Gen. & Sp. **1**: 80. *pl. 55*. 1824.
"*Azeredia* Arruda; Allem. Appar. Coll. Desenh. Arruda, *cum tab.* 1846."
Type species *M. regia* Mart. & Schrank.

KEY TO SPECIES

Leaves palmate-lobed, the lobes serrate.
  Leaves 7-lobed, the lobes lanceolate, subcaudate-acuminate. 1. *M. codinae.*
  Leaves 3- to 7-lobed, the lobes obovate to oblong, acuminate to obtusish.
    Shrub 2 meters high; leaves 10 to 12 cm. wide; capsule glabrate, obtuse. 2. *M. regia.*
    Tree up to 8 meters high or more; leaves 10 to 33 cm. wide; capsule densely griseous-tomentellous, umbilicate. 3. *M. vitifolia.*
Leaves digitately 3- to 7-foliolate, the leaflets entire.
  Leaflets 3; anthers with a single terminal pore. 4. *M. triphylla.*
  Leaflets 5 to 7 (rarely 3); anthers with 2 terminal pores.
    Middle leaflet 10 to 18 cm. long.
      Middle leaflet 2 cm. wide; capsule glabrous, about 25 mm. long. 5. *M. tetrapora.*

[4] Genus named and one species (*Bombax gossypium* L.) cited, but no description or diagnosis.

Middle leaflet 3 to 6.5 cm. wide; capsule densely puberulous, 6 to 7.5 cm. long. 6. *M. orinocensis.*

Middle leaflet 5 to 7.5 cm. long.

Leaflets very obtuse, long-attenuate at base. 7. *M. parkeri.*

Leaflets abruptly acuminate, sessile. 8. *M. paviaefolia.*

1. **Maximilianea codinae** (Eichl.) Kuntze, Rev. Gen. Pl. 1: 44, as *Maximiliana.* 1891.

Cochlospermum codinae Eichl. in Mart. Fl. Bras. 13[1]: 431. *pl. 86, f.1.* 1871.

Leaves 7-lobed, the lobes lanceolate, subcaudate-acuminate, glaucescent beneath; two outer sepals oblong-ovate, subacute, the three inner rounded; petals three times as long; capsule obovate-oval in outline, obtusely 5-angled, 5-valved.

TYPE LOCALITY: Banks of the Río Pará, Brazil.

Described by Eichler from a drawing by Codina.

2. **Maximilianea regia** Mart. & Schrank, Flora 2: 452. 1819.

Wittelsbachia insignis Mart. & Zucc. Nov. Gen. & Sp. 1: 81. *pl. 55.* 1824.

Bombax hibiscifolium Willd.; Mart. & Zucc. Nov. Gen. & Sp. 1: 81, as synonym.[5] 1824.

Cochlospermum insigne St. Hil. Pl. Us. Bras. *pl. 57.* 1827.

"*Azeredia pernambucana* Arruda; Allem. Appar. Coll. Desenh. Arruda, *cum tab.* 1846."

Cochlospermum insigne var. *pohliana* Eichl. in Mart. Fl. Bras. 13[1]: 430. 1871.

Shrub about 2 meters high; branchlets pubescent at apex; petioles puberulous, 8 to 14 cm. long; leaves about 10 to 12 cm. wide, 3- or 5-lobed for three-fourths their length, the lobes oboval or ovate-oblong, acuminate to obtusish, pubescent beneath at maturity, the middle lobe 8 to 12 cm. long, 4 to 5 cm. wide; panicle pyramidate, the lower branches 2- to 4-flowered, the upper 1-flowered; pedicels 1.5 to 2.5 cm. long, tomentellous; flowers 6 to 8 cm. wide; two outer sepals ovate or oblong, subacute or obtuse, puberulous, the three inner 16 to 20 mm. long, 12 to 14 mm. broad, less pubescent; petals subquadrate-obovate, usually emarginate; stamens free, the anthers dehiscent by an apical pore; ovary with 3 to 5 placentae; capsule 3- to 5-valved, oblong-pyramidal, obtuse, 7 cm. long, glabrate; seeds reniform, 6 to 7 mm. wide, involved in dense whitish wool.

TYPE LOCALITY: Eastern Brazil.

RANGE: Provinces of Pernambuco, Goyaz, Bahia, and Minas Geraes, Brazil.

Not seen; the description compiled from those of Martius and Zuccarini and St. Hilaire, and from Eichler's[6] account in the *Flora Brasiliensis.* The capsule is said to have the odor of dill (*Anethum graveolens*). The filamentous bark, according to Eichler, is used for making rope. St. Hilaire states that a decoction of the roots is used for internal troubles, principally those resulting from falls or other accidents, and that this decoction is said to heal abscesses. He gives the native name as "butua do curvo."

[5] Wrongly referred to this species, according to Eichler.

[6] Fl. Bras. 13[1]: 429–431. *pl. 86, f. 2.* 1871.

The typical form has the leaves somewhat pubescent beneath. The form described as var. *pohliana* by Eichler, with slightly larger and thicker always 3-lobed leaves, seems unworthy of recognition. Two other varieties, which appear sufficiently distinct for recognition by name, are the following:

Maximilianea regia glaberrima Chod. & Hassl. Bull. Herb. Boiss. II. **3**: 810. 1903.

Leaves strictly glabrous.

Described from *Hassler* 4934, from Nundurucay, and 4392, from the Río Capibary, Paraguay. Said to be a shrub 30 to 40 cm. high.

Maximilianea regia mattogrossensis (Pilger) Blake.

Cochlospermum insigne var. *mattogrossensis* Pilger, Bot. Jahrb. Engler **30**: 176. 1901.

Leaves densely and shortly cinereous-tomentose beneath.

Described from *Pilger* 518, from the upper Cuyabá Valley, Matto Grosso. Said to be a shrub with several unbranched stems from a thick rootstock.

3. **Maximilianea vitifolia** (Willd.) Krug & Urb. Bot. Jahrb. Engler **15**: 293, as *Maximiliania*. 1892.

Bombax vitifolium Willd. Enum. Hort. Berol. **2**: 720. 1809.

Cochlospermum serratifolium DC. Prodr. **1**: 527. 1824.

Bombax serratifolium [Moc. & Sessé;] DC. Prodr. **1**: 527, as synonym. 1824.

Maluria ? speciosa Choisy in DC. Prodr. **1**: 558. 1824.

Wittelsbachia vitifolia Mart. & Zucc. Nov. Gen. & Sp. **1**: 82. 1824.

Cochlospermum hibiscoides Kunth, Syn. Pl. Aequin. **3**: 214. 1824.

Cochlospermum vitifolium Willd.; Spreng. Syst. **2**: 596, in part. 1825; Syst. **4**: Cur. Post. 206. 1827.

Maximiliana hibiscodes Kuntze, Rev. Gen. Pl. **1**: 44. 1891.

Large or small tree; branchlets at first loosely pilose; petioles more or less pubescent, glabrate, 8 to 28 cm. long; leaves usually 5-lobed, rarely 3- or 7-lobed, for one-half to three-fourths their length, 10 to 33 cm. wide, above more or less puberulous along the impressed veins, beneath loosely pilose along the veins and in youth along the chief veinlets, the lobes oblong to oval or obovate-oval, short-pointed or abruptly short-acuminate; inflorescence sordid-pubescent, the axis 3 to 9 cm. long, the spreading or ascending branches several-flowered toward the tip; pedicels densely puberulous or tomentulose, 2 to 3 cm. long; flowers 7.5 to 12.5 cm. wide; two outer sepals ovate to oblong-ovate, obtuse to rounded, sparsely or densely puberulous, 10 to 12 mm. long, the three inner broadly oval, rounded, finely and densely cinereous-puberulous, 16 to 22 mm. long; stamens free, the anthers opening by an apical pore and 2 minute basal pores; capsule broadly obovate-oval, 7 to 8 cm. long, about 6 cm. thick, densely griseous-tomentellous, 5-valved, umbilicate at apex; seeds involute-reniform, 4.5 mm. wide, involved in long whitish wool.

ILLUSTRATION: Hemsl. Biol. Centr. Amer. Bot. *pl. 2*.

TYPE LOCALITY: "Brazil" (*i. e.*, Campeche, *fide* Mart. & Zucc.).[7]

RANGE: Western Mexico, from Sinaloa and Guerrero to Chiapas and Yucatan, southward to Colombia (Santa Marta, *H. H. Smith* 830), and reported from Venezuela and Guayaquil;[8] also Cuba (introduced).

The species bears the following local names, many of which have been furnished me by Mr. Paul C. Standley: "rosa amarilla" (Sinaloa, where the

[7] MART. & ZUCC. Nov. Gen. & Sp. **1**: 82. 1824.

[8] H. B. K. Nov. Gen. & Sp. **7**: 223. 1825.

orange inner bark is used for making ropes); "palo amarillo," "palo de rosa amarilla" (Durango); "panaco" (Acapulco, Guerrero); "madera de pasta" (Veracruz, *Ramírez*); "apompo," "pongolote," "cojón de toro" (Oaxaca); "pochote" (Tabasco, Oaxaca); "cocito" (Chiapas); "tecomasúchil" (Chiapas, Guatemala); "quie-riga," "quie-quega," "huarumbo," "flor izquierda" (Chiapas and Oaxaca, *Scler*); "chuun," "chum," "chimu" (Maya, Yucatan); "tecomaxochitl" (Nahuatl); "tecomasuche" (Guatemala); "bombón," "catamericuche" (Nicaragua); "poró-poró" (Nicaragua, Panama, Costa Rica, Colombia); "flechero," "batabana," "bototo" (Venezuela, Colombia); "botija" (Cuba). Kunth[9] mentions the local names "botulo" (Guayaquil) and "carnestolendas" (Aragua, Venezuela). The branches root readily if thrust into the ground, and are frequently used to form hedges.

The original description of this species is so brief that it would not suffice to distinguish between *M. regia* and *M. vitifolia* as generally adopted. Willdenow gives the locality as Brazil, but Martius and Zuccarini, who examined the original in the Willdenow Herbarium, accredit it to Campeche, and their statement is here taken as authority for the use of the name in its generally accepted sense. *Mahuria ? speciosa*, which was based by Choisy on a single flower collected at Santa Marta by Bertero, is considered by St. Hilaire, who examined the original, as scarcely distinct from *M. regia*. It is clear, however, from the good specimen collected at the same locality by Herbert H. Smith, that the name belongs rather to *M. vitifolia*.

The ovary of *Cochlospermum hibiscoides* was wrongly described by Kunth as glabrous.

4. **Maximilianea triphylla** Blake, sp. nov.

Small tree; branchlets glabrous, lenticellate; petioles glabrous, 12.5 to 16 cm. long; leaflets 3, on petiolules 1 to 2 mm. long, the blades nearly membranaceous, the terminal one obovate-oval, 14.5 cm. long, 7.8 cm. wide, short-pointed with obtuse apex, broadly cuneate at base, glabrous, entire, marginate, light green, the chief nerves about six pairs, curved, ascending at an angle of about 60°, the secondary veins somewhat prominulous; lateral leaflets similar, oval, inequilateral, 12.5 cm. long, 6 cm. wide; flowering axis 6 cm. long, with about 5 short horizontal branches, sordid-puberulous toward the tip, each bearing toward apex about 4 flowers; pedicels obscurely puberulous, 2.8 cm. long; sepals 5, the two outer elliptic-oblong, rounded, sordid-pilose, dark colored, about 1.7 cm. long, 6 mm. wide, the three inner suborbicular, broadly rounded, densely canescent-pilosulous, 2 cm. long; petals 5, cuneate-obovate, apparently emarginate at apex, bright yellow, 5 cm. long, 2 to 2.5 cm. wide; stamens very numerous, with free glabrous filaments, the anthers yellow, linear, 4.8 to 6 mm. long, dehiscing by a single terminal pore and two minute basal pores; ovary densely tomentose, 5-celled; style glabrous, 3.5 cm. long.

Type in the U. S. National Herbarium, no. 1,065,095, collected in hedges at Valencia, Venezuela, April (flowers) and July (leaves), 1920, by H. Pittier (no. 8930).

[9] H. B. K. Nov. Gen. and Sp. 7: 223. 1825.

Fig. 1. *Maximilianea triphylla* Blake. *a*, leaves, × 1/2; *b*, inflorescence after defloration, × 1/2; *c*, flower, × 1/2; *d*, bud, × about 1/2; *e*, stamen, × 2 1/2.

This species is readily distinguished by its combination of digitate leaves and single apical anther pore. *M. tetrapora*, which is said by Hallier to have the leaves occasionally with three leaflets, is easily separated by its much smaller calyx, much narrower lanceolate leaflets, and anthers with two apical pores.

5. **Maximilianea tetrapora** (H. Hallier) Blake.

Cochlospermum tetraporum H. Hallier, Med. Rijks Herb. **19**: 39. 1913.

?Cochlospermum zahlbruckneri Ostermeyer, Rep. Sp. Nov. Fedde **13**: 395. 1914.

Leaves long-petioled, at first sparsely pilose, the leaflets 5 to 7, rarely 3, very shortly petiolulate, the blades lanceolate, membranaceous, with a very narrow acumen at apex, attenuate at base, the two basal ones inequilateral, the middle leaflet 10.5 cm. long, 2 cm. wide; peduncles dichotomous, glabrous; pedicels 2.5 cm. long, glabrous; sepals ovate or elliptic, 10 to 12 mm. long, 5 to 8 mm. wide, the inner densely puberulous and ciliolate; petals obovate, excised, 4 cm. long, 2.5 cm. wide; anthers 3 to 4 mm. long, dehiscing by two apical and two smaller basal pores; capsule fusiform-subglobose, glabrous, 2.3 cm. long, 1.8 cm. wide.

TYPE LOCALITY: Caipipendi Valley, Bolivia.

Not seen; described by Hallier from *Herzog* 1101, collected on dry hills on the left bank of the Pilcomayo at Ibibobo, Bolivia, at an altitude of 400 meters, in November, 1910, and *Herzog* 1242, from the Caipipendi Valley, altitude 1000 meters, December, 1910. As the material of the former number consisted only of three flowers, the latter should be selected as the type.

The short description by Ostermeyer of his *Cochlospermum zahlbruckneri* agrees very well with the full description given by Hallier of *C. tetraporum*, and there can be little question that the two are the same. The former was based on material collected by J. Schuel in 1913 in the Province of Jujuy, Argentina, a region very close to the type locality of *M. tetrapora*. Ostermeyer gives the local name of his species as "palo papel." The reddish brown papery exfoliating bark of *M. tetrapora* is likewise mentioned by Hallier.

6. **Maximilianea orinocensis** (H. B. K.) Kuntze, Rev. Gen. Pl. **1**: 44, as *Maximiliana*. 1891.

Bombax orinocense H. B. K. Nov. Gen. & Sp. **5**: 301. 1822.

Wittelsbachia orinocensis Mart. & Zucc. Nov. Gen. & Sp. **1**: 83. 1824.

Cochlospermum orinoccense (*sic*) Steud. Nom. ed. 2. **1**: 393. 1840.

Tree 16 meters high; branchlets puberulous at apex; leaves long-petioled, the leaflets 5 or rarely 6, lanceolate or oblong, acuminate, at base acute, glabrous above, puberulous along the nerves beneath, the middle one 10 to 18 cm. long, 3 to 6.5 cm. wide; axis of inflorescence thinly tomentose above, the pedicels puberulous; sepals ovate or ovate-oblong, thinly tomentose; flowers 10 to 11 cm. wide; calyx 10 to 18 mm. long; petals cuneate-obovate, excised at apex; stamens free, the anthers dehiscent by 2 terminal pores; capsule 3-locular, about 7.5 cm. long, thinly tomentose outside; seeds twisted, clothed with a long wool.

TYPE LOCALITY: Banks of the Orinoco.

The above description is compiled from the original, based on fragmentary fruiting specimens, and from the descriptions of Martius and Zuccarini and of Eichler. The native name is given as "botuto." It is recorded by Eichler from the provinces of Para (*Spruce* 483) and Alto Amazonas (*Spruce* 494).

In the National Herbarium is a single sheet of fruiting material labeled as this species, collected at Catalina on the Lower Orinoco by Rusby and Squires (no. 256). This has 5-foliolate leaves, with the sessile elliptic acuminate and apiculate perhaps not mature leaflets 10 to 11.5 cm. long or more, 3 to 4 cm. wide, glabrous above, beneath puberulous along the costa and chief veins. The capsules are obovate, slightly umbilicate at apex, 3-valved, 6 cm. long, 3 cm. thick, very densely olivaceous-puberulous and with sparse looser and longer hairs. The seeds are involute, 4 mm. wide, and clothed with a peripheral fringe of rufidulous wool about 9 mm. long. In the only other species of which I have examined the seeds, *M. vitifolia*, the much looser and denser wool is attached to the whole outer surface of the seed, on the sides as well as on the back.

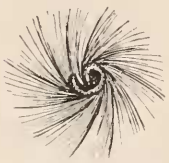

Fig. 2. Seed of *Maximilianea orinocensis*, × 1. Drawn from *Rusby & Squires* 256.

7. **Maximilianea parkeri** (Planch.) Kuntze, Rev. Gen. Pl. 1: 44, as *Maximiliana*. 1891.

Cochlospermum parkeri Planch. Lond. Journ. Bot. 6: 310. 1847.

Petioles very thinly puberulous, about 7.5 cm. long; leaflets 5, oblong, very obtuse, at base long-attenuate, glabrous, the terminal one 5 to 7.5 cm. long, 2 to 3.5 cm. wide, the two lowest less than half as large; peduncle bifurcate at apex, the flowers secund along the branches.

TYPE LOCALITY: British Guiana.

Not seen. Described from material in the Kew Herbarium, collected by Parker.

8. **Maximilianea paviaefolia** (Planch.) Kuntze, Rev. Gen. Pl. 1: 44, as *Maximiliana pawiaefolia*. 1891.

Cochlospermum parviaefolium (sic) Planch. Lond. Journ. Bot. 6: 311. 1847.

Cochlospermum parkiaefolium (sic) Hook. & Jacks. Ind. Kew 1[1]: 576. 1893.

Leaflets 5, sessile, oblong, abruptly acuminate, glabrous, the middle one 7.5 cm. long, 2.5 to 3.7 cm. wide; pedicels 1.2 cm. long or more; sepals broadly oblong, obtuse, slightly unequal, rufo-tomentellous outside; petals twice as long.

TYPE LOCALITY: Surinam.

Not seen; based on material in the Kew Herbarium, collected by Hostmann.

OCEANOGRAPHY.—*The problem of physical oceanography.*[1] A. L. THURAS. (Communicated by S. W. STRATTON, Bureau of Standards.)

Physical oceanography is that branch of oceanography which deals with the physical properties of the ocean such as temperature, salinity, density, pressure, velocity and direction of water movements, for the

[1] Received January 31, 1921.

purpose of solving the general problems of oceanic circulation. This article is written with the object of indicating the importance of this subject, especially as regards a part of the North Atlantic ocean, from the light of recent experience, and with the hope that in the near future some systematic plan of work will be undertaken to solve the important dynamical problems of the sea, thereby obtaining a more accurate knowledge of ocean circulation.

During recent years much work of an explorational nature has been carried on in the coastal waters of the United States and Canada. Dr. Henry B. Bigelow, in cooperation with the U.S. Bureau of Fisheries, has made these investigations, and the results of his work are published in the Bulletins of the Museum of Comparative Zoology, Harvard University. Several theories of the origin and circulation of our coastal waters have been corrected, and sufficient data have been collected to give a general working knowledge of the subject. Valuable observations have also been collected by observers in Canadian waters, and from these observations some exceedingly interesting theories of ocean circulation have been developed by J. W. Sandstrom. Most of this work has also been of an explorational nature.

Since the beginning of the International Ice Patrol an opportunity has been given to extend this work further out into the North Atlantic in the region of the Grand Banks of Newfoundland and in the Labrador Current and Gulf Stream. The conflict of the Labrador Current and Gulf Stream south of the Newfoundland Bank causes greater changes in the physical properties of the sea water, only a few miles apart, than occur in any other part of the world. The hydrographical conditions which exist in this locality cause much ice and fog which become a serious menace to navigation during the spring and summer months. The vessels of the U. S. Coast Guard have collected many observations while on patrol in this region. These observations have so far been chiefly of an explorational nature, as the primary purpose of the Patrol has necessarily been to locate ice and convey this information to other vessels. However, from the data obtained and the admirable current charts prepared by Captain C. E. Johnston of the Coast Guard, a fairly accurate knowledge of the movements of ice after passing Newfoundland is available.

In the spring icebergs from the shores of Greenland and Labrador are carried southward in the Labrador Current, their movement being little affected by winds, on account of their small buoyance. Those bergs which are sufficiently off shore to clear the bottom and keep in

the south-flowing branch of the Labrador Current are carried along the eastern edge of the Newfoundland Bank and southward toward the Gulf Stream. By measurements of temperature and salinity the course and extent of these streams can be determined, salinity generally being the most reliable indication. The temperature of the Labrador Current is $-1°$ to $+1°$ C., with a salinity of 33 grams of salt per 1000 grams of sea water; the Gulf Stream has a temperature of 15° to 20° C., with a salinity of 36. South of the Grand Bank, where the Labrador Current merges into the Gulf Stream, a large area of mixed water is formed, and at this place the Labrador Current ceases as an individual current. In this mixed water almost all the icebergs remain until they melt, and, as this area is usually very foggy from the mixing of the warm and cold waters, it becomes extremely dangerous for vessels. At no time during the last four years has an iceberg ever been located in the unmixed waters of the Gulf Stream, which have a salinity of 36 and a temperature above 15° C. Therefore, if vessels while passing the Newfoundland Bank would keep in this warm salt water there would be little danger from ice, and furthermore such a course would avoid most of the fog.

A comparison of the yearly observations show that the volume and strength of the Labrador Current have a decided influence on the course of the Gulf Stream in this vicinity. In some years the Gulf Stream was found almost up to the southern end of the Grand Bank, in other years as far south as the 40th degree of north latitude, a variation of over 100 miles. This variation in the deflecting power of the Labrador Current must have an effect on the volume of flow of the Gulf Stream to the eastward and also possibly west of this position. A more accurate knowledge of the volume, velocity, and location of these currents from time to time, and correlation with meteorological conditions, might yield results of great interest.

SUGGESTIONS FOR FUTURE WORK

The science of physical oceanography, having passed the period of exploration, should now be undertaken on a large scale with most carefully worked out plans of systematic investigation extending over a long period of time. This can be most effectively accomplished by: (1) international cooperation; (2) development of instruments; (3) establishment of a permanent oceanographic laboratory.

International cooperation.—The oceanographers of Europe for many years have been engaged in the study of the North Sea and surrounding waters. They have built many ingenious instruments and

developed several new methods of investigation. They have been especially interested in the waters of the Gulf Stream, on account of its effect on their climate, and would be very glad to cooperate with us in a careful study of this Stream.

Development of instruments.—In order to obtain a clearer and more complete understanding of the dynamics of ocean circulation, an effort has been made in recent years to develop recording instruments. Hans Pettersson of Göteborg, Sweden, has built a photographic recording current meter which will give a continuous record of current velocity and direction for a period of two weeks. By the use of special anchors and buoys the instrument can be firmly anchored at any depth up to several hundred meters. Dr. R. A. Daly of Harvard University has recently had constructed a thermograph which will give a continuous record of temperature for a week or more; this instrument can be used at great depths in the ocean. The U. S. Coast Guard in conjunction with the Bureau of Standards has designed and constructed a recording salinity apparatus and a recording thermometer which will give continuous records of temperature, salinity and density of the sea water taken from intake pipes below the surface by a moving vessel. As all of these instruments have been developed independently, it might be possible by cooperation and further research to develop a single instrument which would give all of these physical properties at each oceanographic station.

Oceanographic laboratory.—A physical oceanographic laboratory should be established where instruments could be tested and improved and research carried on. This laboratory should be located in Washington, preferably at the Bureau of Standards, where there are facilities for handling and developing work in scientific instruments.

SUMMARY

The physical oceanographic observations collected in our Atlantic waters indicate that that stage in development has been reached which calls for more thorough plans of work extending over a long period of time. These investigations can be accomplished most successfully by international cooperation, development of physical oceanographic instruments, and establishment of a permanent oceanographic laboratory.